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## MINE FURNACE VENTILATION.

BY JOHN BAILLIE.

I present this paper on Mine Management," on the subject will not be out of place:  
Furnace Ventilation with some hesitation, for I have no doubt that "We may safely affirm that there  
most of the members of this Institute are better qualified to handle is no subject more worthy of the  
attention of the mining student  
the subject than myself. than that of ventilation, to which

To introduce this paper I think we have now come, bearing as it  
a few lines from "Hyslop's Colliery does so much on the comfort and

safety of the men, and appealing, through them, to all the better feelings of those in charge. For the machinery that lowers the workmen down the shaft; the timber that protects them when there, and the various appliances which lighten the burden of toil, the coal operator must give largely of the capital which he can often ill spare; but the fresh air which those men require is one of God's 'good and perfect gifts, without money and without price.' No matter where the shaft is situated it is there unfailing, pure and plentiful; and all he is asked to do is to be at the expense of conducting it through the winding galleries whence his profits come; an expense which in most cases, is comparatively trifling; and where judiciously applied, materially assists in lessening the cost of producing the coal.

The object of having a ventilating furnace is to strengthen and guide the natural current, which it does by imparting additional heat to the upcast column, and so lessening its density and specific gravity. When any volume, by contact with the fire, is thus lightened, it is no longer able to resist the pressure of the volume behind, and is pushed forward into the upcast shaft; so that no sooner does any portion of the current come over the fire than it is pushed beyond it; and the more quickly and the higher the temperature is raised, the greater will be the velocity of the stream, and the larger the quantity of air put in circulation. Like all gaseous bodies air expands by contact with heat, and an increase of temperature always increases the volume, and lessens the weight when the

pressure is the same, and it is found that the rate of expansion is an equable one, and equal to 1-459 of volume for every additional degree of heat.

The motion of air is caused by a difference of pressure, thus, if the air in an upcast shaft be raised to a temperature of 200 degrees, and the temperature of the air in the downcast 62 degrees, and both shafts are 100 feet in depth, the column of air in the upcast shaft would be 1.598 pounds lighter than the column of air in the downcast shaft. This would be the pressure per square foot producing the current of air in the mine; which pressure in the open air would produce a velocity of wind nearly 18 miles per hour. This is found by the formula  $v = \sqrt{200 \times p}$ ,  $b =$  the velocity in miles per hour, and  $p =$  the pressure in pounds per square foot. Of course the velocity of the air in the mine would not be as much as this on account of so much resistance the air encounters in passing through the air courses of the mine.

In the mine where I am employed the ventilating furnace is situated 24 feet from the bottom of the upcast shaft, and the shaft is 60 feet in height; its area is 25 square feet. The area of the furnace bars is 25 square feet; the area of the furnace is 18 square feet; and the space on top and sides, for a current of air to travel between furnace and coal roof and sides, 20 square feet.

Out of several measurements to find the amount of air travelling per minute I selected one taken on October 5th. The temperature of the air outside was 48 degrees, and in the upcast shaft 184 degrees. The amount of air passing per min-

ute was 20,800 cubic feet. From the above data we will find the motive column for this shaft. The motive column is a head of air of such a height that it will equal the difference between the weight of the downcast and upcast columns of air. The motive column for any ventilating furnace in the downcast shaft can be found by this formula:

$$M = D \times \frac{t - t'}{t - 459}$$

M = the motive column, D = the depth of shafts; t = the temperature of the upcast shaft; and t' = the temperature of the downcast shaft. Now, we will substitute the above figures for the letters in the formula, thus:

$$60 \times \frac{184^\circ - 48^\circ}{184^\circ - 459} = 12.6905 \text{ feet of}$$

motive column. That is, divide the difference of the temperatures of the two shafts by 459 plus the temperature of the upcast shaft, and multiply this result by the height of the shaft. The result is the length of the motive column, and, if we take the square root of this motive column and multiply it by 8, we would have a velocity of the per second in the upcast shaft of 28.48" feet; that is, if it did not meet any resistance passing through the air-courses in the mine. Then the velocity of the air per minute would be  $60'' \times 28.48' = 1708.8$  feet. But instead of having this amount of velocity in the upcast shaft we have only 832 feet per minute. This is found by dividing the 20,800 cubic feet by the area of the upcast shaft, thus:

$$\frac{20,800}{25} = 832,$$

and we found above that the motive column gave us a velocity of

1,708.8 feet per minute; which is a little more than double the velocity I get in the upcast shaft. This shows that one-half of the velocity is lost in passing through the mine, rubbing against the sides, roof and bottom—this is called friction. And this must be considered a very small loss, for it is found in practice in the English mines that 7-8 up to 19-20ths of all the pressure is taken up to overcome the friction. That is,  $\frac{1}{2}$  up to 1-20 of ventilating pressure is creating its final velocity at the top of the upcast shaft. Suppose the pressure per square foot is 1 lb for the velocity of 832 feet per minute, the pressure per square foot for the velocity of 1,708.8 feet would be 4.2 lb, thus:  $832^2 : 1,708.8^2 :: 1 : 4.2$  lbs. pressure. Now we will find the weight of the two columns of air in the downcast and upcast shafts to get the units of work or horse power of the furnace. But, before we proceed further, we will give the formula for finding the weight of a cubic foot of air at any temperature or height of barometer. It has been found by careful experiments that 459 cubic feet of air at 0° Fahrenheit's scale weighs 39.76 pounds when the pressure is 30 inches; but when the pressure is 1 inch, weighs only 1-30 part of this, or 1.3253 pounds. Then the weight of a cubic foot of air, at any temperature and pressure, will =  $W = \frac{1.3253 \times B}{459 - t}$ , B = the barometer in inches, t = the temperature of Fahrenheit's thermometer; W = the weight of a cubic foot of air. A large proportion of the mines in this State do not have two shafts. This makes no difference if the in-take is on the same level as the bottom of the

upcast shaft. The imaginary downcast is the same height as the upcast shaft; but, if the in-take is 10 feet below the level of the upcast shaft, then the height of the downcast would be 10 feet more than the upcast shaft, &c. Now, the weight of a column of air in the imaginary downcast shaft 60 feet in height is 4.7 pounds, and the weight of the column of air in the upcast shaft 60 feet in height is 3.7 pounds, nearly, the barometer being 30 inches. So, if we subtract the latter from the former, the difference will be just 1 lb, nearly, of pressure per square foot; or more correctly .995 pounds, thus :

$$\frac{1.3253 \times 30}{459 - 48^\circ} \times 60 - \frac{1.3253 \times 30}{459 - 184^\circ} \times 60$$

= .995 pounds. This is a very small pressure for the amount of air travelling. There are two causes for this. The first is that the areas of the entries and air-courses are about 70 square feet, and the second cause is that the butt entries are nearly driven square on the butts of the coal, making the sides of the entries very smooth for long distances, and the horse power for this furnace is not quite  $\frac{3}{4}$  of a horse power. It is found thus: Multiply the amount of cubic feet per minute by the pressure, and divide the result by

$$33,000, \text{ thus } H P = \frac{q p}{33,000} =$$

$$\frac{20,800 \times .995}{33,000} = .627. \quad q = \text{the}$$

quantity of air per minute; p = the pressure in pounds; H P = the horse power. If we wanted to know the co-efficient of friction for this mine we would proceed thus: The length of air-courses is 7,000 feet. Let this = l; a = the area

of the same  $10 \times 7 = 70$  feet. The perimeter of air-course is  $10 + 10 + 7 + 7 = 34$  feet = O. The surface of the air-courses will =  $l \times O = S$ , which is 238,000 feet. The velocity of the air in the air-courses will =

$$\frac{q}{a} = \frac{20,800}{70} = 297.143 \text{ feet, =}$$

velocity per minute; p = .995 lbs. pressure, and k = the co-efficient

$$\text{of friction; then } k = \frac{p a}{s v^2} =$$

$$\frac{.995 \times 70}{238,000 \times 88,294} = .000000003314 \text{ lbs.}$$

for a velocity of 1 foot per minute, and for a velocity of 1,000 feet per minute k would = .003314 pounds per square feet of area of section. This co-efficient of friction is about seven times less than the late Mr. J. J. Atkinson, Inspector of mines in England, used in his work on "Gases Met with in Coal Mines." The co-efficient of friction in his work is 0.0217 pounds for a velocity of 1,000 feet per minute. In the above I said the entries had an area of 70 square feet. Most of the entries and air-courses have this area, but some of them are  $14 \times 8$  feet, or 112 feet area. But the refuse of the vein that is slate bone and soft coal is built along one side of the entries, and the refuse that is made in turning rooms, is built there also; so I think the entries of 70 square feet area are as good as the large entries for conducting the air. There is one thing I want to call your attention to. The volume of air in the return airway passes through an old room  $8 \times 20$  or 160 square feet of area, and 300 feet long. If we divide the 20,800 cubic feet by this area the velocity of the air will equal 130 feet per minute, and if we find the

pressure producing this velocity in would not be practicable in most the 300 feet room will be found mines to have such large air-ways 169.2 times less than the whole as this, but it shows what can be pressure, that is .995 pounds, then done when we have a small power for this pressure we would have a to produce the current of air length of air-ways equal to 169.2 through the mine.

rooms 300 feet long, or a little more If the above practical questions than 50,000 feet long, instead of on furnace ventilation assist any 7,000 feet and 70 square feet area. member of this Institute, or those This shows us that very extensive that hold the same position as my-mines can be ventilated with a very self, I shall be satisfied for the time small power by enlarging the area I have taken to put these few lines of the air-ways. Of course it together.

